

Collaborations in continuous monitoring in the Delaware River Basin: a case study from Willistown Conservation Trust

National Monitoring Conference, 2019, Denver, CO

Lauren McGrath
Director of Watershed Protection Program

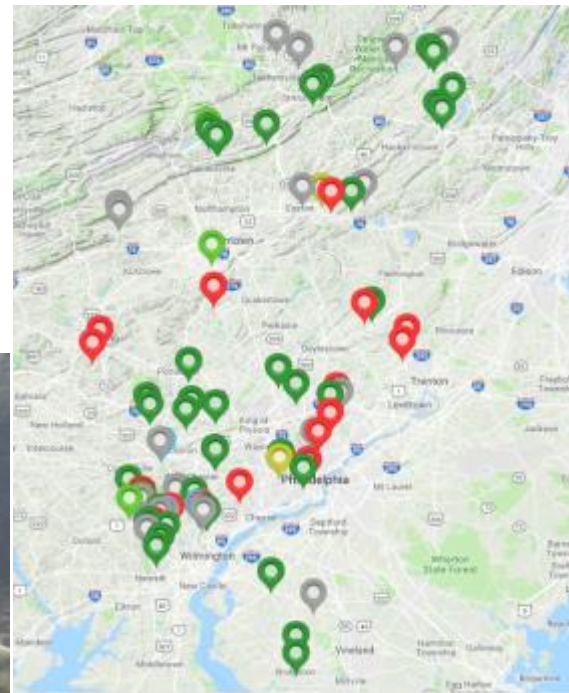


David Bressler



Intentions for presentation

- Overview of the evolving Delaware River Basin EnviroDIY sensor station network, a *citizen science* project
- Case study from Willistown Conservation Trust



Background

- Part of the William Penn Foundation's Delaware River Watershed Initiative - 4states1source.org
 - Restoration and Protection
 - Education
 - Science capacity building, ability to monitor and track change



Background

- Delaware River Basin EnviroDIY sensor station network
 - EnviroDIY.org



An Initiative of Stroud Water Research Center

About ▾ Community ▾ Mayfly ▾ Blog Forums ▾ Videos Help Register Log In 🔍

Subscribe EnviroDIY on GitHub



Welcome to EnviroDIY, a community for do-it-yourself environmental science and monitoring. EnviroDIY is part of [WikiWatershed](#), a web toolkit designed to help citizens, conservation practitioners, municipal decision-makers, researchers, educators, and students advance knowledge and stewardship of fresh water. **New to EnviroDIY?** [Start here](#)



Check out the [EnviroDIY Mayfly Data Logger](#), a powerful user-programmable microprocessor board that is fully compatible with Arduino IDE software.



For sketches, libraries, and documentation, [visit our EnviroDIY GitHub repository](#).

COMMUNITY ACTIVITY

[SEE ALL ACTIVITY >](#)



Shannon Hicks replied to the topic **Attaching a Campbell Scientific OBS3+ turbidity sensor to Mayfly** in the forum **Mayfly Data Logger**

6 days, 18 hours ago

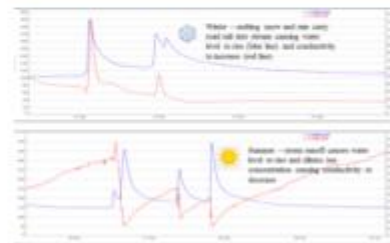
The OBS sensor comes with bare-wire cable with 6 leads. Three of them need to be connected to the Mayfly ground (sensor power ground, sensor signal ground, and sensor shield). Then the 3 other sensor wires get connected to the remaining 3 pins of a Grove terminal (note, you have to use one of the two Aux A/D Grove inputs only). [Seedstudio...\[Read more\]](#)



fisherba replied to the topic **Attaching a Campbell Scientific OBS3+ turbidity sensor to Mayfly** in

ENVIRODIY BLOG

[SEE ALL >](#)



EnviroDIY Sensors Track Road Salt Levels in Streams

© 2018-02-06

BLOG COMMENTS

Ask a Question

Have a question about DIY environmental monitoring? Post it in the forum.

[Start a forum topic](#)

FORUM TOPICS

[ACTIVITY >](#)

ESP8266

© 2019-02-13

FORUM REPIES

Background

- People: volunteers, students, professors, managers, scientists
- Over 30 watershed groups, schools, universities
- >70 stations, many online, public
- Stroud Water Research Center support via deployments, guidance materials, manuals, data sheets, workshops, etc.

Citizen science context

Generating data for answering ecological questions

AND

Building science capacity among watershed groups

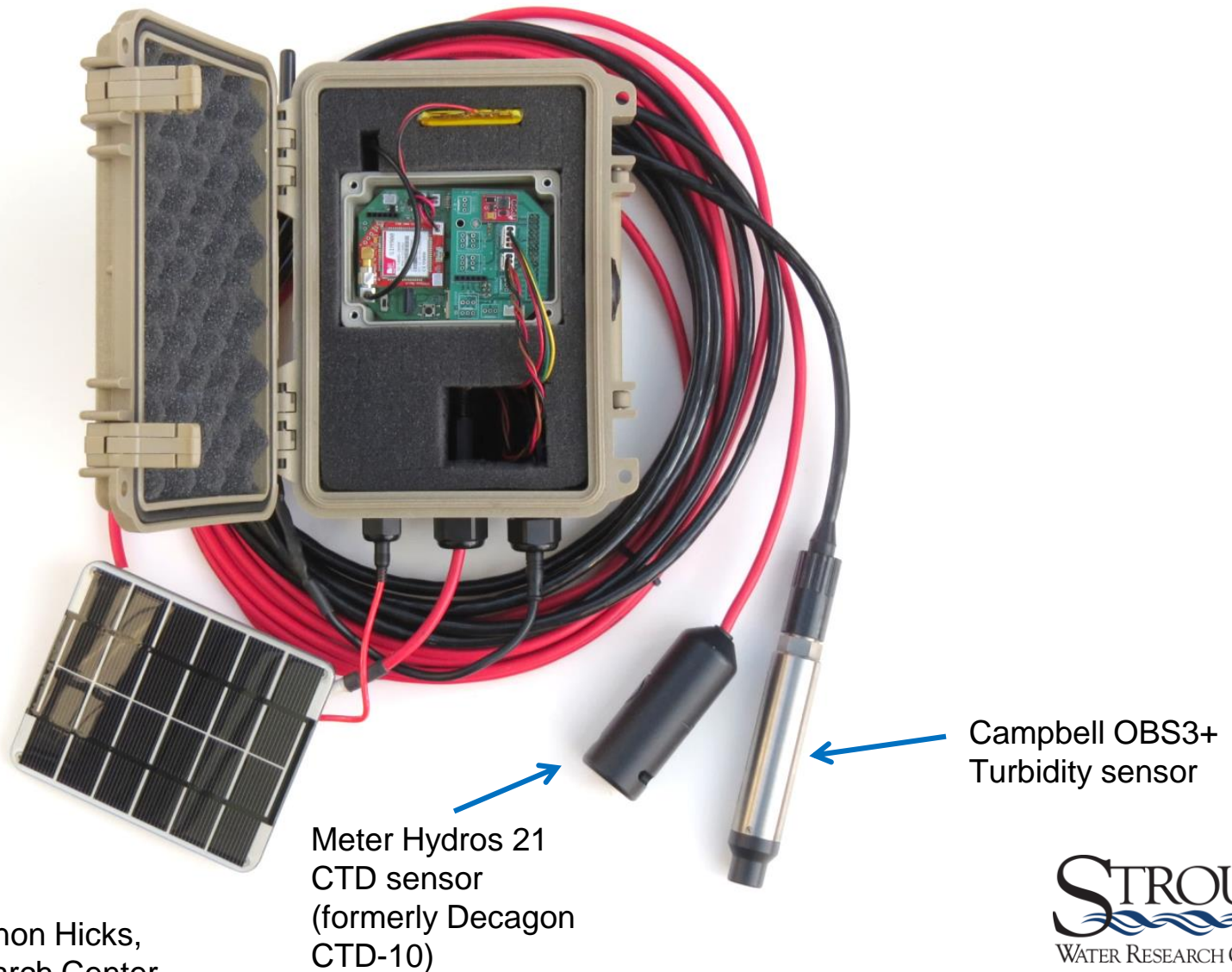
AND

Building cultural science literacy (a unique benefit of citizen science efforts), first hand experience, watching things change

Delaware River Basin EnviroDIY sensor network

- Sensor stations deployed with groups throughout the Delaware River basin
 - Primary focus: groups use for own questions, education
 - Stroud Center support
 - Secondary: building a basin-wide data set – mostly small streams
 - Ongoing conversation about the broader analysis

CTD (conductivity, temperature, depth) and Turbidity



*Designed by Shannon Hicks,
Stroud Water Research Center

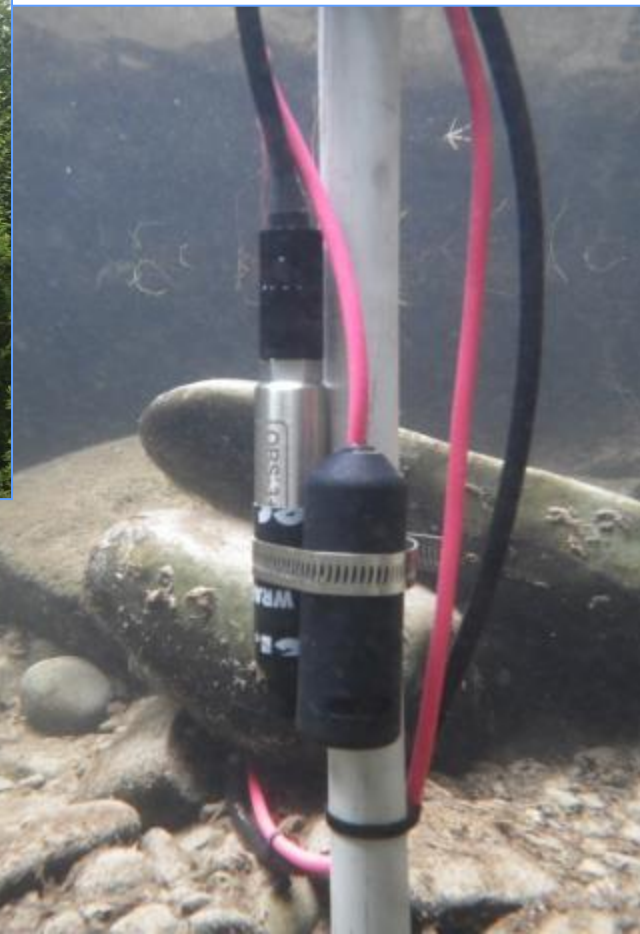
Mayfly data logger



Fully compatible with Arduino
IDE software

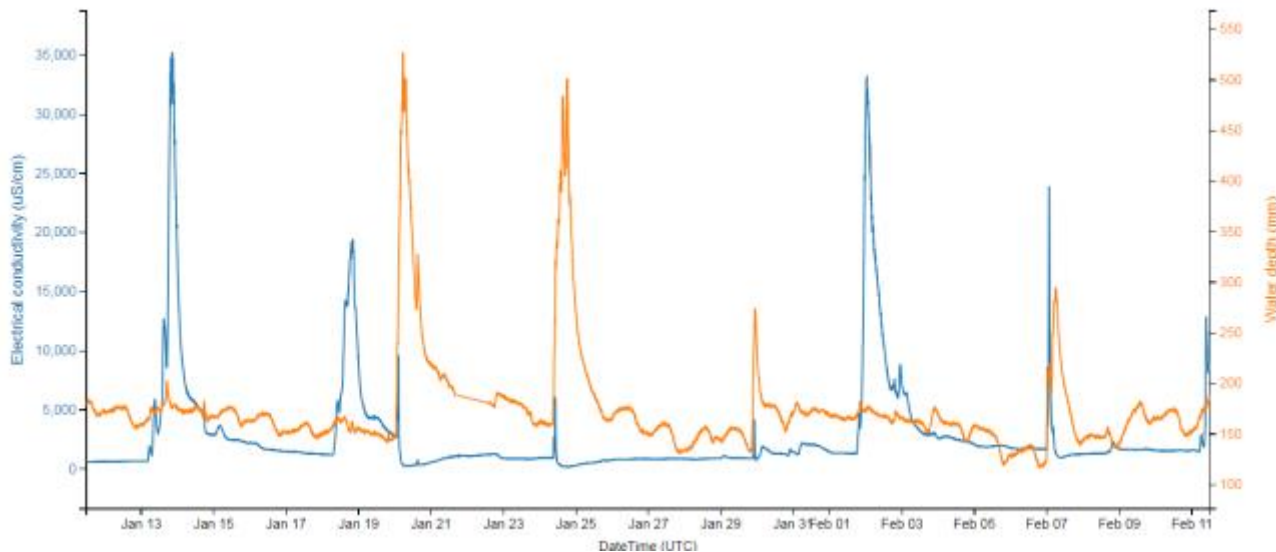
*Designed by Shannon Hicks, Stroud Water
Research Center

EnviroDIY Sensor Stations

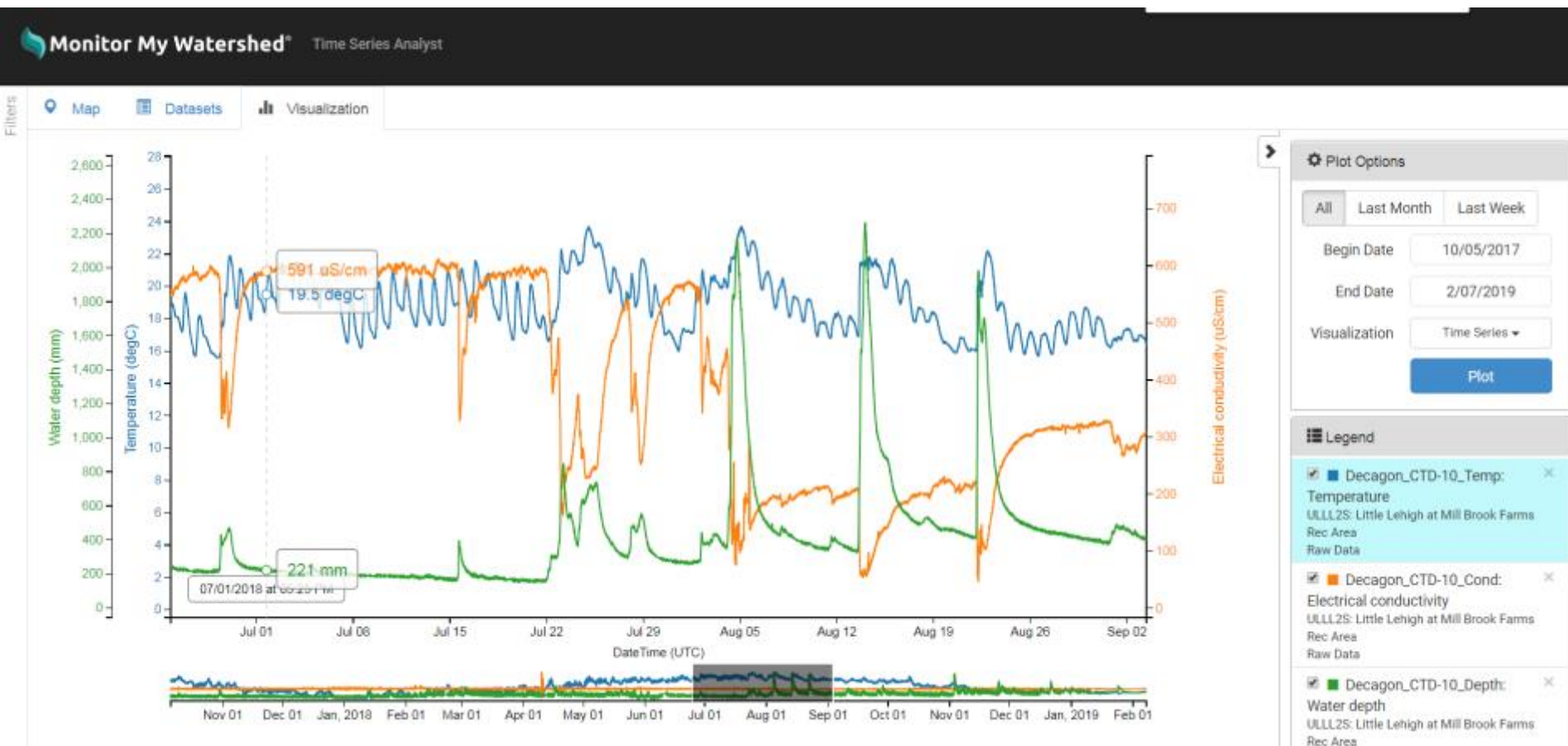


Sensor stations

- Continuous data = measurements every five minutes
 - Real-time, sometimes, depends on cell signal - <http://MonitorMyWatershed.org/>
 - On-site (microSD card) – all the time
 - Online – all the time (soon), upload data file to **Monitor My Watershed**



Continuous data – every 5 min, online, sometimes real-time



Resources

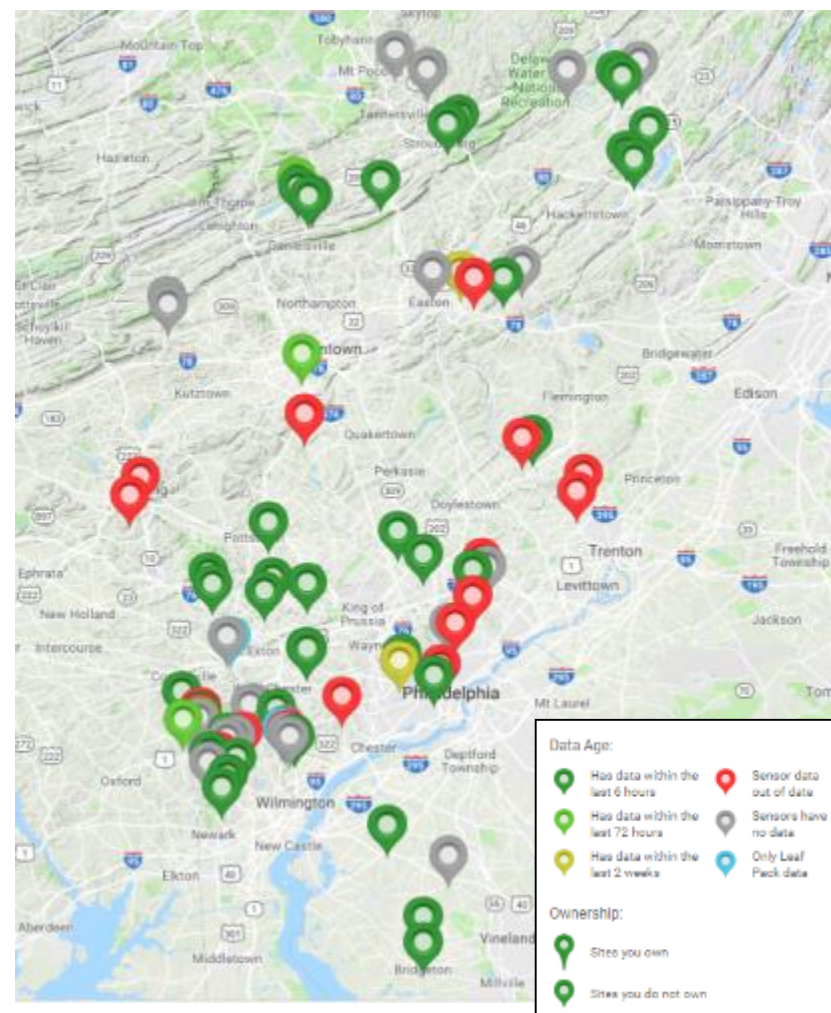
- **People**
 - Extensive collaborations
 - Contributors lists included here
 - Volunteers/citizen scientists, professional scientists, managers, teachers, students
- EnviroDIY Mayfly Sensor Stations – EnviroDIY.org
- Workshops, trainings, assistance visits, 1:1
- Online tools – WikiWatershed.org
 - [Monitor My Watershed](#)
 - [Model My Watershed](#)
- Delaware Basin Sensor Stations online group
- Manuals and guidance materials
- Data sheets
- Data analysis tools – Stage to Area predictor, discharge rating curve calculator, load calculator

Workshops and trainings

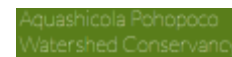
- Sensor Station User Group Gatherings
 - Next one presentations on questions, issues, successes – feedback and support
- Sensor station management
- Intro to EnviroDIY – programming, building, data
- Watershed 101
- **Discharge and TSS, rating curves and loads**
- Data analysis
- Science practice
- Stormwater, hydrology
- Model My Watershed
- Small group custom trainings
- Assistance and troubleshooting visits



Collaboration



BARTRAM'S GARDEN



AMERICAN LITTORAL SOCIETY
Caring for the Coast



WHITE CLAY CREEK
National Wild & Scenic River
Ours to Enjoy. Ours to Protect.



The Great Marsh
Institute



Tookany/Tacony-Frankford
Watershed Partnership, Inc.



Wildlands
Conservancy
Lasting connections to nature since 1973



Woodstown High School
Learning is our mission
Once a Wolverine, Always a Wolverine



Group support – super important “Core Group”

Dr. Paul Wilson – East Stroudsburg University

- Undergraduate and graduate
- DRWI cluster monitoring
- 5 stations

Kent Himelright – Berks Co. Cons. District

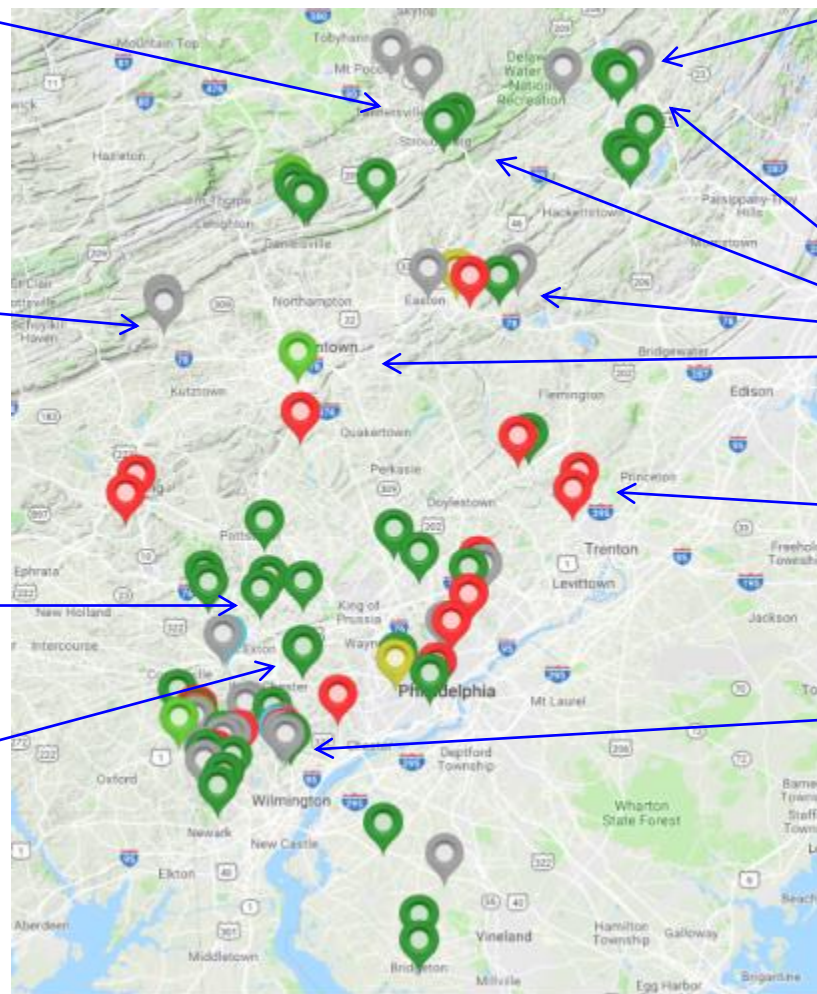
- Tracking agricultural restoration
- 3 stations

Carol Armstrong – Penn State Master Watershed Stewards

- Workshops and trainings
- Field assistance
- 2 stations

Lauren McGrath – Willistown Conservation Trust

- Regional monitoring
- Sediment, old mill dam areas
- 2 stations, 2 additional in process



Nancy Lawler – Musconetcong Watershed Association

- Dam monitoring, treatment plant discharge
- >3 stations, collaborations with NJ Trout Unlimited

Christa Reeves – East Stroudsburg University, Stroud Center, Musconetcong Watershed Association

- Research on Cherry Ck
- Multiple stations

Steve Tuorto, The Watershed Institute

- Urban trends
- 2 stations

Kim Hachadoorian – The Nature Conservancy, DE

- Collaboration with First State National Historical Park
- Building TNC Stream Stewards
- 6 stations

User roles

- Upkeep/maintenance
- Data entry
- Quality Control
- Storm sampling
- Data management
- Training/workshops
- Rating curves, loads
- Sleuthing based on data

Upkeep/maintenance



EnviroDIY Field Visit Data

Enter all data online: wikiwatershed.org/drwi; password: drwi

Name(s):		LoggerID:	
Site ID:		Location:	
Stream Name:		Date: Arrival Time: AM/PM? *EST/EDT?	
GPS (Lat/Long):		*EST=Eastern Standard Time; EDT=Eastern Daylight Time (Daylight Savings)	
Photos? Yes/No		Water Clarity (Clear, Cloudy, Muddy):	
Precipitation last 24 Hours? Yes/No Amount:			
General Notes/ Photo Descriptions:			

SENSOR CLEANING (Recommended frequency: weekly or biweekly; monthly if only CTD sensor)			
*Cleaned Sensors? Yes/No If Yes, exact time:		AM/PM?	*EST/EDT?
*Clean >5 min. before grab sampling			

GRAB SAMPLES (Rec frequency: Situational; for rating curves, collect when water is high/turbid or higher than normal conductivity)			
Grab Sample Taken? Yes/No		Time collected (to minute): AM/PM? EST/EDT?	
Sample Number:		Volume:	
Bottle Type:		Date Shipped:	
Lab Sent To:		Notes:	

*SENSOR STATION DATA TO MATCH WITH GRAB SAMPLE LAB RESULTS (Complete in field or office)			
Sensor station Conductivity (uS/cm):	Time (military):	Not applicable	Always EST
Sensor station Turbidity (NTU):	Time (military):	Not applicable	Always EST

*For use in Turbidity/TSS and Conductivity/Chloride rating curve development. Record sensor station Cond and Turb data at time nearest to grab sample collection time. Can be completed in field (by accessing online data) or in office (online or download from microSD card). Acquire final grab sample lab results from Stroud Center (or lab that processed sample).

QUALITY CONTROL - WATER LEVEL DATA (Rec frequency: quarterly and/or more frequently as needed)			
*Staff Gauge Height (m):	Time:	AM/PM?	EST/EDT?
*Sensor Station Water Depth (mm):	Time (military):	Not applicable	Always EST
*QC Sensor Station Water Depth (mm):	Time:	AM/PM?	EST/EDT?
Offset (=Staff Gauge Height - Sensor Station Water Depth)(mm):			

a - Staff Gauge Height and Sensor Station Water Depth readings should be from about the same time (+/- 5 minutes).
b - Use metric ruler to measure from pressure transducer (white disc in CTD sensor) to water surface. Note - this depth measure may be slightly different from the sensor-measured depth but should be consistent over time.

Data entry and data management

STROUD
WATER RESEARCH CENTER
www.stroudcenter.org

EnviroDIY Field Visit Data

Enter all data online: wikiwatershed.org/drwi; password: drwi

Name(s): _____

Site ID: _____

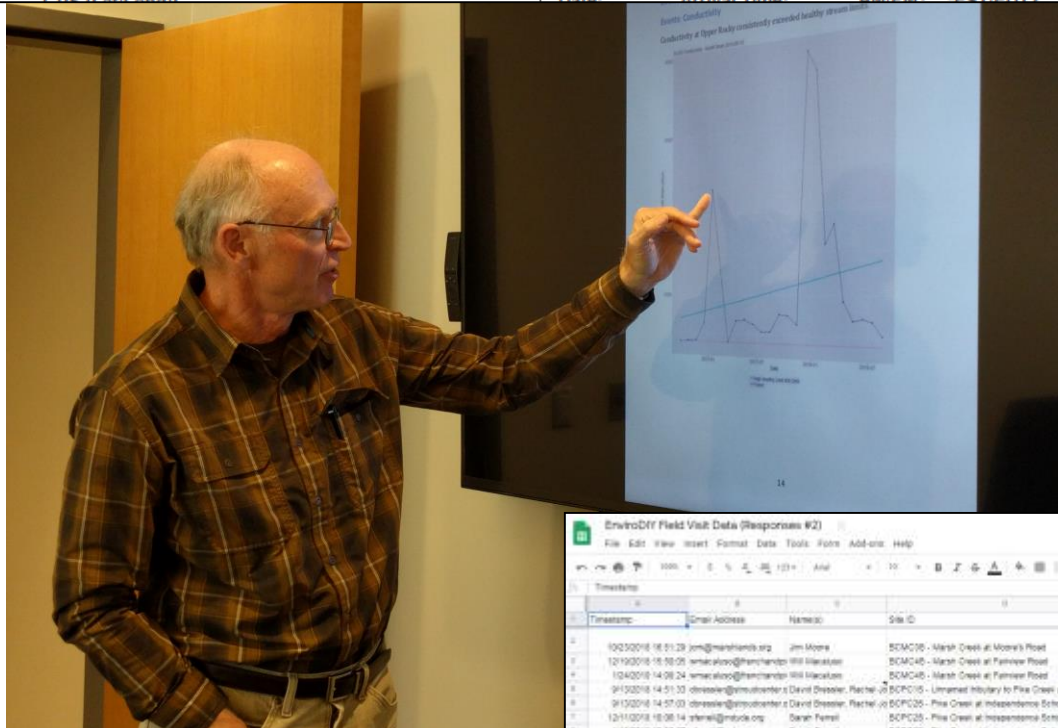
Stream Name: _____

GPS (lat/long): _____

LoggerID: _____

Location: _____

Date: _____ Arrival Time: _____ AM/PM? _____ *EST/EDT?



EnviroDIY Field Visit Data

If you have trouble with this form, please contact webmaster@stroudcenter.org

Please enter your email so we can send you a copy of your submitted data and a link for editing.

* Required

Email address *

Your email _____

Name(s)

Your answer _____

EnviroDIY Field Visit Data (Responses #2)

File Edit View Insert Format Data Tools Print Add-ons Help

Working...

Timestamp	Email Address	Name(s)	Site ID	GPS latitude	GPS longitude	Photo?	Precipitation (last 24 hours)	Precipitation amount	Precipitation units	Generate photo data Logger ID
10/23/2018 18:51:29	jrm@manhills.org	Jim Moore	SCMC05 - Marsh Creek at Moore's Road			Yes	Yes			After snow event where to SL150
12/19/2018 15:50:05	smcclary@manhills.org	Will Mcclary	SCMC05 - Marsh Creek at Palmer Road			Yes	Yes			Banker breached. Steady to SL150
10/20/2018 14:08:24	smcclary@manhills.org	Will Mcclary	SCMC05 - Marsh Creek at Palmer Road			Yes	Yes			Installed CTD station with SL150
9/13/2018 14:51:33	dbressler@stroudcenter.org	David Dresher, Rachel	BCPC05 - Unnamed tributary to Pine Creek at Independence	36.745101	-75.715844	Yes	Yes	0.1 inches		Installed CTD station with SL150
9/13/2018 14:57:03	dbressler@stroudcenter.org	David Dresher, Rachel	BCPC05 - Pine Creek at Independence School	36.743697	-75.716483	Yes	Yes	0.1 inches		Installed CTD station with SL150
12/11/2018 18:08:14	stern@stroud.org	Sarah Stern	BCPC05 - Pine Creek at Independence School	36.743697	-75.716483	Yes	Yes	8 inches		
11/5/2018 18:26:07	stern@stroud.org	Sarah Stern	BCPC05 - Pine Creek at Independence School			Yes	Yes			Students assisted in cleaning out the
2/6/2019 11:01:24	stern@stroud.org	Sarah Stern	BCPC05 - Pine Creek at Independence School			Yes	Yes			
7/30/2018 14:12:40	landman@stcloud.org	Tim Zaton	BCRC05 - Red Clay, West Branch at Sunrise Preserve			Yes	Yes	5x	inches	Wettest of a heat wave. to SL150
8/17/2018 11:07:04	landman@stcloud.org	Tim Zaton	BCRC05 - Red Clay, West Branch at Sunrise Preserve			Yes	Yes			Major flooding event. 24 to SL150
11/9/2018 18:46:47	landman@stcloud.org	Tim Zaton	BCRC05 - Red Clay, West Branch at Sunrise Preserve			Yes	Yes			Significant rainfall. 40 hours prior
12/19/2018 15:18:12	landman@stcloud.org	Tim Zaton	BCRC05 - Red Clay, West Branch at Sunrise Preserve			Yes	Yes	1 inches		SL150
11/9/2018 15:36:27	landman@stcloud.org	Tim Zaton	BCRC05 - Red Clay, West Branch at Sunrise Preserve			Yes	Yes	Insignificant two-minute snow flurry		SL150

Quality Control



QUALITY CONTROL - WATER LEVEL DATA (Rec frequency: quarterly and/or more frequently as needed)

*Staff Gauge Height (m):	Time:	AM/PM?	EST/EDT?
*Sensor Station Water Depth (mm):	Time (military):	Not applicable	Always EST
*QC Sensor Station Water Depth (mm):	Time:	AM/PM?	EST/EDT?

Offset (=Staff Gauge Height - Sensor Station Water Depth)(mm):

a - Staff Gauge Height and Sensor Station Water Depth readings should be from about the same time (+/- 5 minutes).

b - Use metric ruler to measure from pressure transducer (white disc in CTD sensor) to water surface. Note - this depth measure may be slightly different from the sensor-measured depth but should be consistent over time.

QUALITY CONTROL - CHEMISTRY DATA (Rec frequency: quarterly and/or more frequently as needed)

Parameter	QC Hand-held Meter Result	QC Time	QC AM/PM?	QC EST/EDT?	Sensor Station Result	Sensor Station-Time (Military, EST)
Conductivity (uS/cm):			AM/PM	EST/EDT		
Temperature (degC):			AM/PM	EST/EDT		
Turbidity (NTU):			AM/PM	EST/EDT		
Dissolved Oxygen (mg/L):			AM/PM	EST/EDT		

QUALITY CONTROL CHEMISTRY FIELD METER INFORMATION

Parameter	Field Meter Brand/Model/Serial # or unique ID	Meter calibrated?	Standard	Calibration
Conductivity (uS/cm):		Yes/No		
Temperature (degC):		Yes/No		
Turbidity (NTU):		Yes/No		
Dissolved Oxygen (mg/L):		Yes/No		



Storm sampling



- Discharge rating curve calculator
- Stage to area predictor
- Load calculator

Discharge Event Entry & Rating Curve

Starting-off Tutorial

- 1) Click the button to "Add A New Discharge Measurement."
- 2) After about a second, you will be directed to a new sheet named "Discharge Event X" (Where "X" is one number higher than the number of discharge measurements already recorded in this spreadsheet.)
- 3) Warning dialog boxes will come up saying how there are already existing worksheets using similar names, yes/no to all of the warnings.
- 4) After Data Entry into "Discharge Event X"
- 5) The new results should appear on your curve.
- 6) If you see errors or strange values in this sheet, chances are very high you made a mistake in entering data OR you clicked the "Add A New Discharge Measurement" button too many times.
- 7) Make sure that all results are entered correctly and that you do not have any extra un-used sheets.
- 8) Data in the "Discharge Event X" sheets can be corrected easily by clicking on the tabs and checking all values in the WHITE boxes.
- 9) There will need to be a minimum of 5 to 7 Discharge Events ranging from baseflow to peak storm flow that provide different water depths and velocities.
- 10) Once you have a functioning rating curve, you can then click on the "Calculate Discharge" tab.

Note For Deleting Discharge Events: If you have made major errors and want to remove a discharge measurement sheet, you must do the following (this should be considered only as a last resort):

- 1) Delete the offending worksheet by right-clicking on the worksheet tab on the bottom and selecting "delete."
- 2) Unprotect the "Rating Curve" worksheet by clicking "Review"

Add A New Discharge Measurement

Average Offset between Sensor Depth and Stage: #D9/D9

Rating Equation - Discharge to Stage

$$\text{Total Discharge} = \left(\frac{\#VALUE!}{\#VALUE! \times \text{Stage}} \right)^{\#} \times \#VALUE!$$

Rating Equation - Discharge to Stage plus Sensor Depth Offset

$$\text{Total Discharge} = \left(\frac{\#VALUE!}{\#VALUE! \times \text{SensorDepth}} \right)^{\#} \times \#D10/D1$$

Rating Between Stage or Sensor Depth and Discharge

Sleuthing



Case study: WILLISTOWN CONSERVATION TRUST

- Land trust
- New watershed protection program
 - Monitoring
 - Lab work
- Small group – 16 employees; collaborations to support efforts
 - Local universities
 - Other local watershed groups

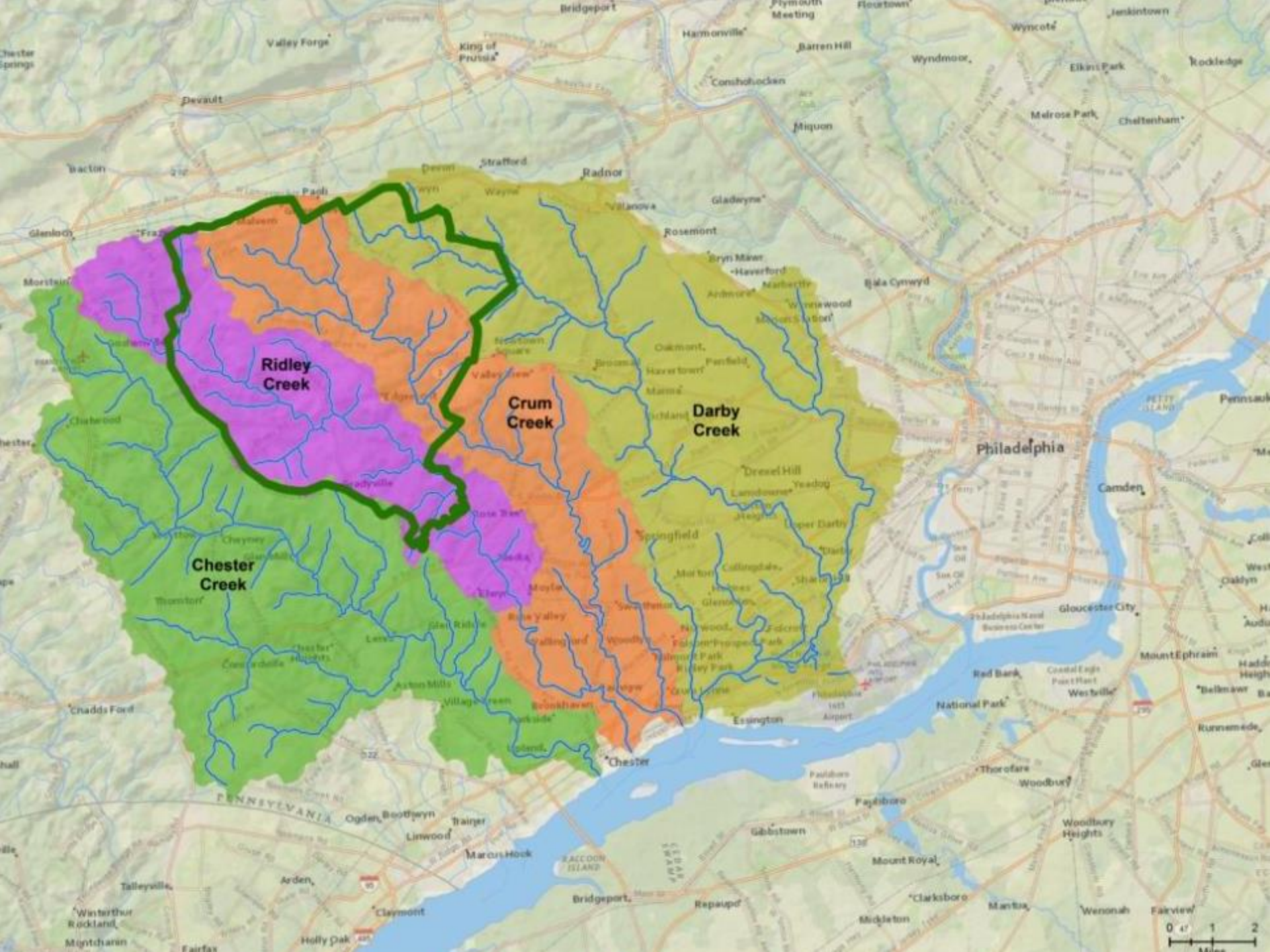
Willistown Conservation Trust

- Land Trust established in 1979
- 28,000 acres in Chester County and portions of Delaware County
- Located approximately 20 miles west of Philadelphia

A person wearing a light blue shirt and dark waders is crouching in a shallow stream, looking down at something in their hands. The stream is surrounded by lush green grass and foliage. The background is a dense forest of green trees.

Watershed Protection at Willistown Conservation Trust

- Explicitly embraces the link between land protection and water quality
- Water stewardship in the headwaters of Ridley, Crum, and Darby Creeks







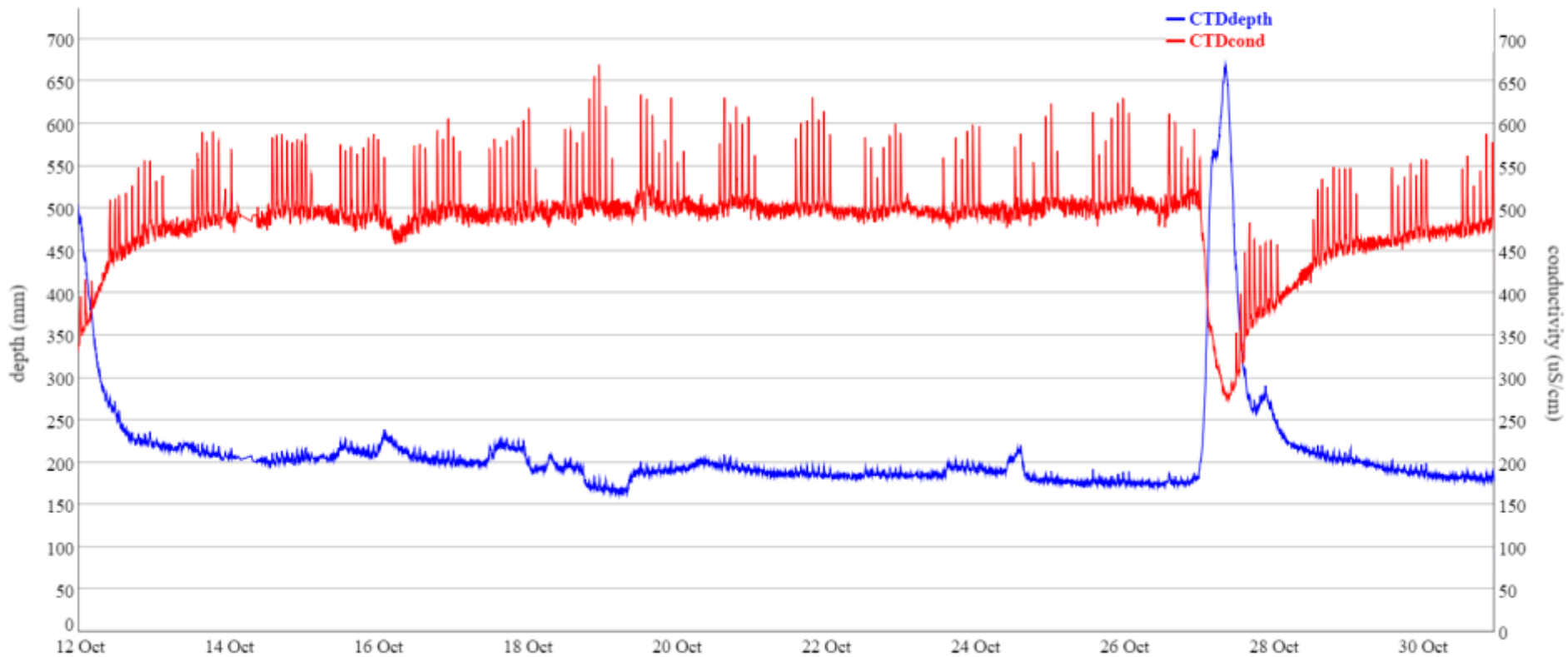
SL155 - Water Conductivity

Water Depth and Conductivity(in uS/cm)

Highlight to zoom in, double-click to zoom out.

Note: you can highlight either vertically or horizontally to zoom the x or y axis

Hold Shift while dragging to pan left and right





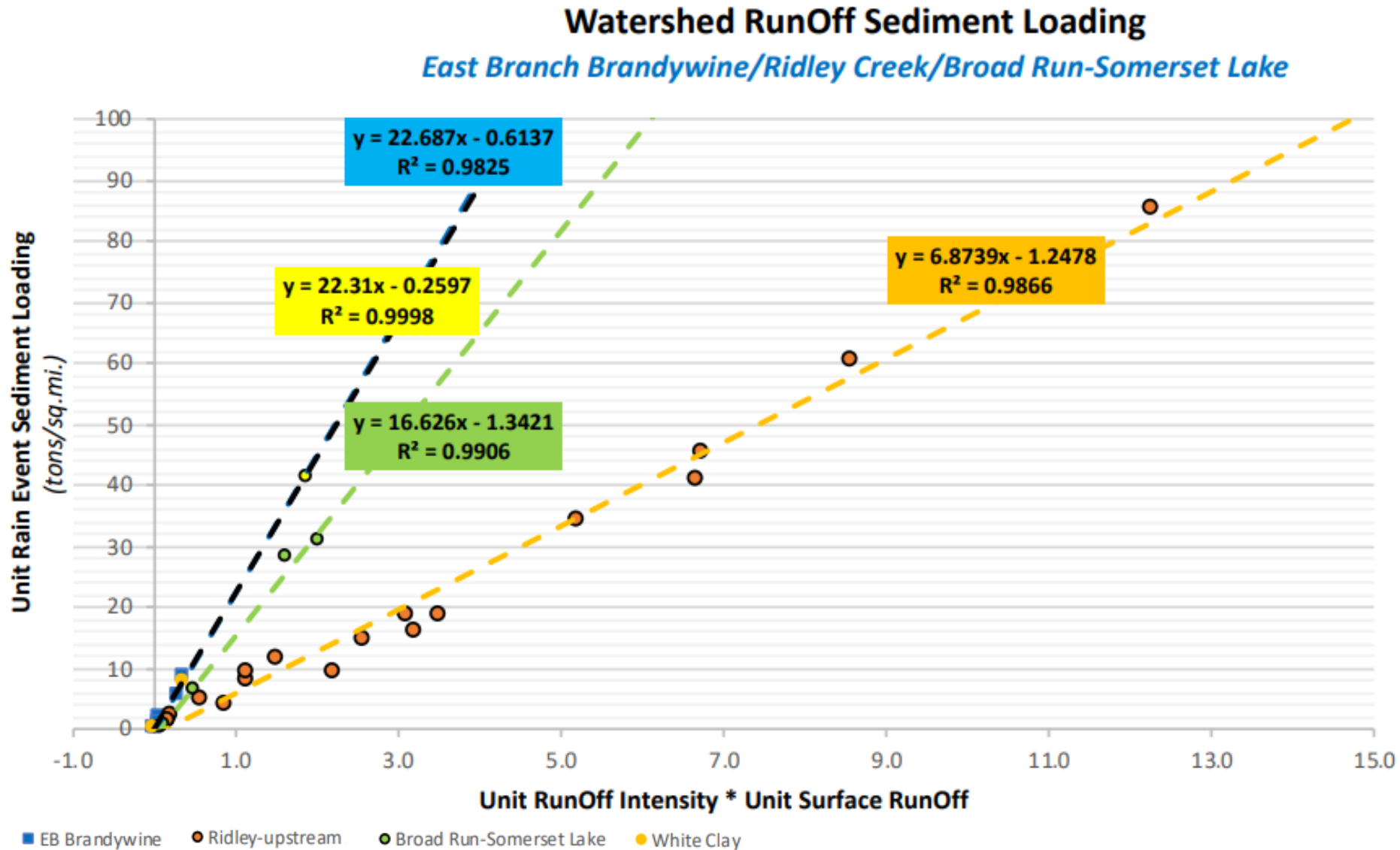
WRAP
10 FT.

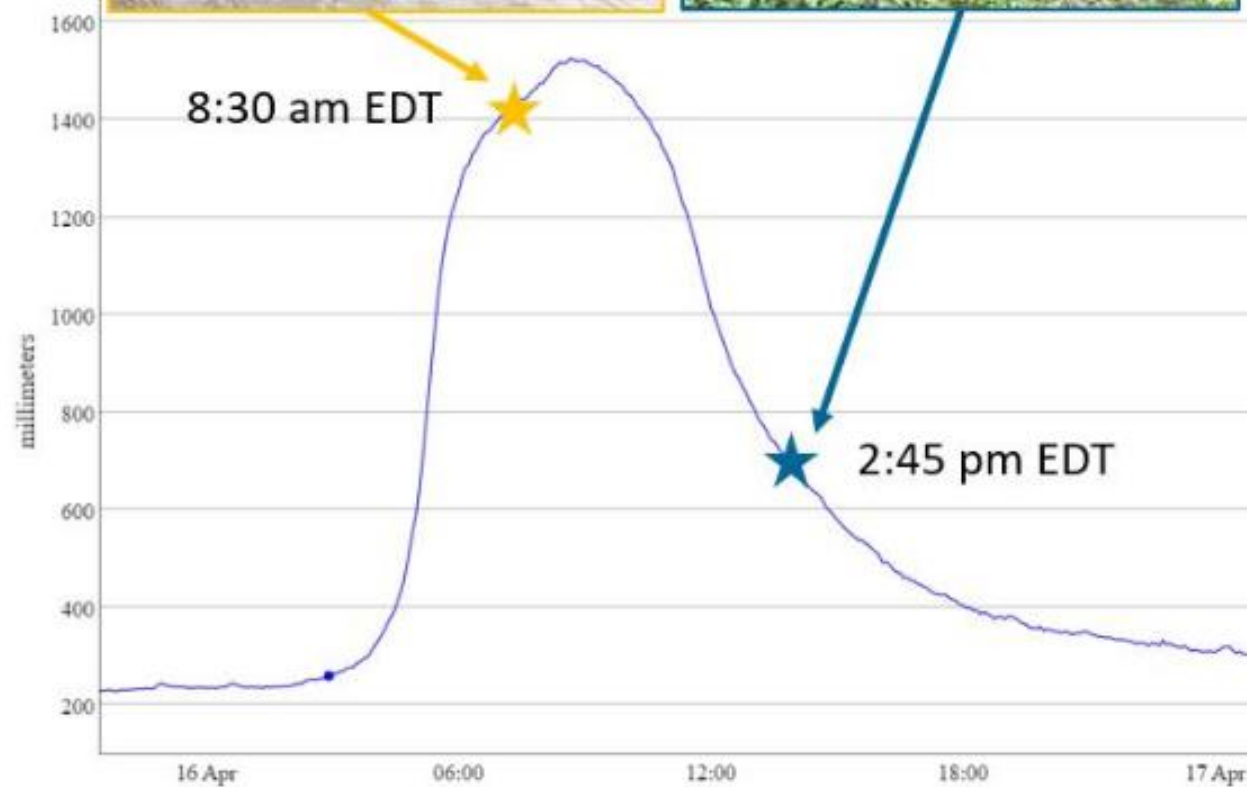






Watershed Hydrological Analysis Team











WILKINTOWN
CONSERVATION TRUST

The Academy of
Natural Sciences
of Pennsylvania
The Academy of
Natural Sciences
of Pennsylvania

10:54
WBCC1
Turbidity

Wilkintown Conservation Trust Water Chemistry

Filtered
Unfiltered
Date: 2/21/2018
Station ID: WBCC1
Turbidity
Time: 10:54
Wilkintown Conservation Trust Water Chemistry









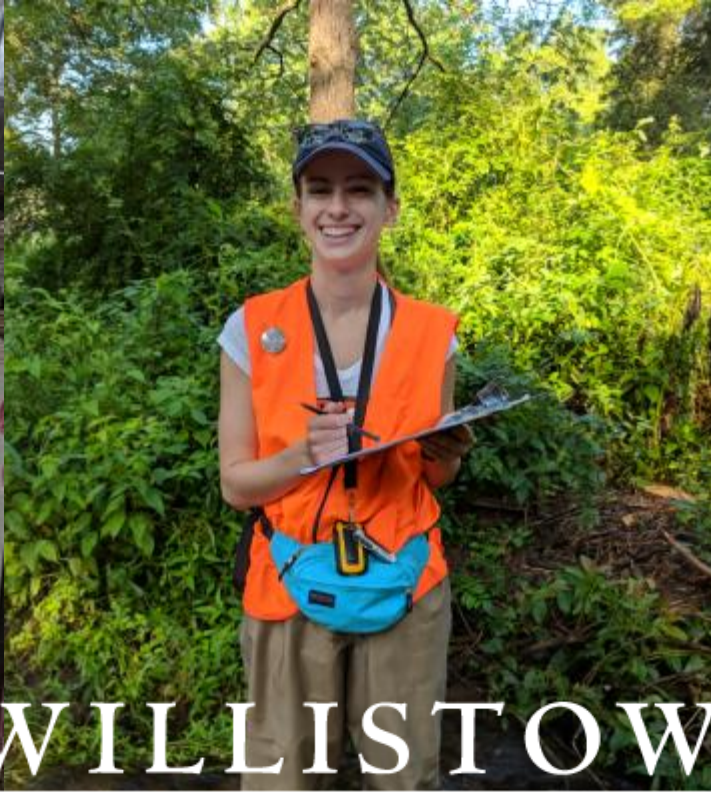








- Generating data for answering ecological questions
- Building science capacity among watershed groups
- Building cultural science literacy



WILLISTOWN
CONSERVATION TRUST





Shannon Hicks
David Arscott
Rachel Johnson
Matt Gisondi
Sara Damiano
Tara Muenz
Carol Armstrong
Christa Reeves
Jennie Matkov
Heather Brooks
Melanie Arnold



Bonnie Van Alen
Kat Gord
Regan Dohm
Prem Trivedi
Anna Willig
Chase Herz
Aish Raja

WHAT

Dave Yake
Bill Ward
Marion
Waggoner

**Utah State
University**

Limnotech

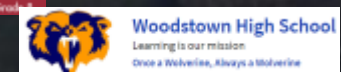
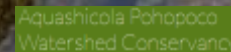
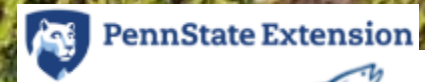


Thank you!

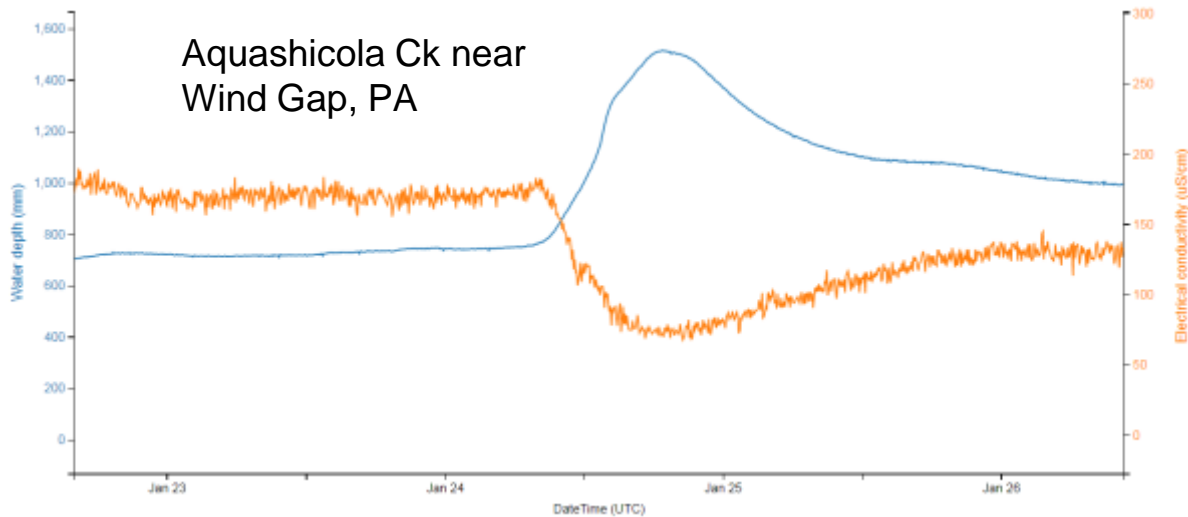
Lauren McGrath
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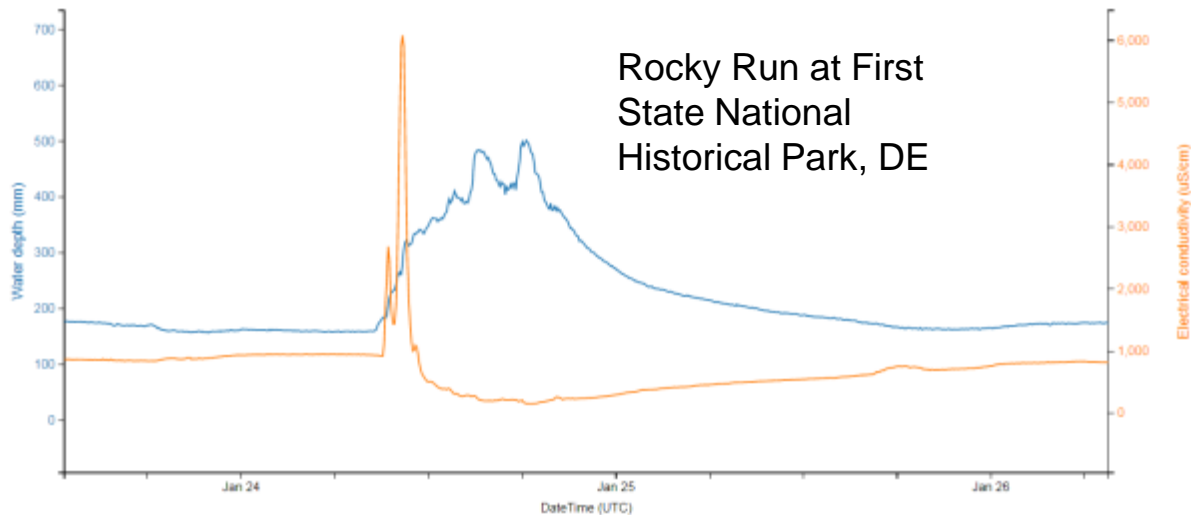
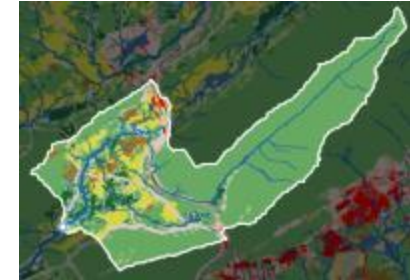
WILLIAM PENN
FOUNDATION



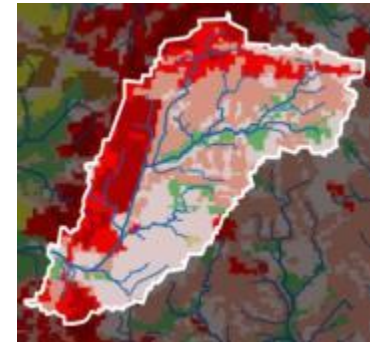
Forested versus Urban – winter conductivity spikes



79% Forest

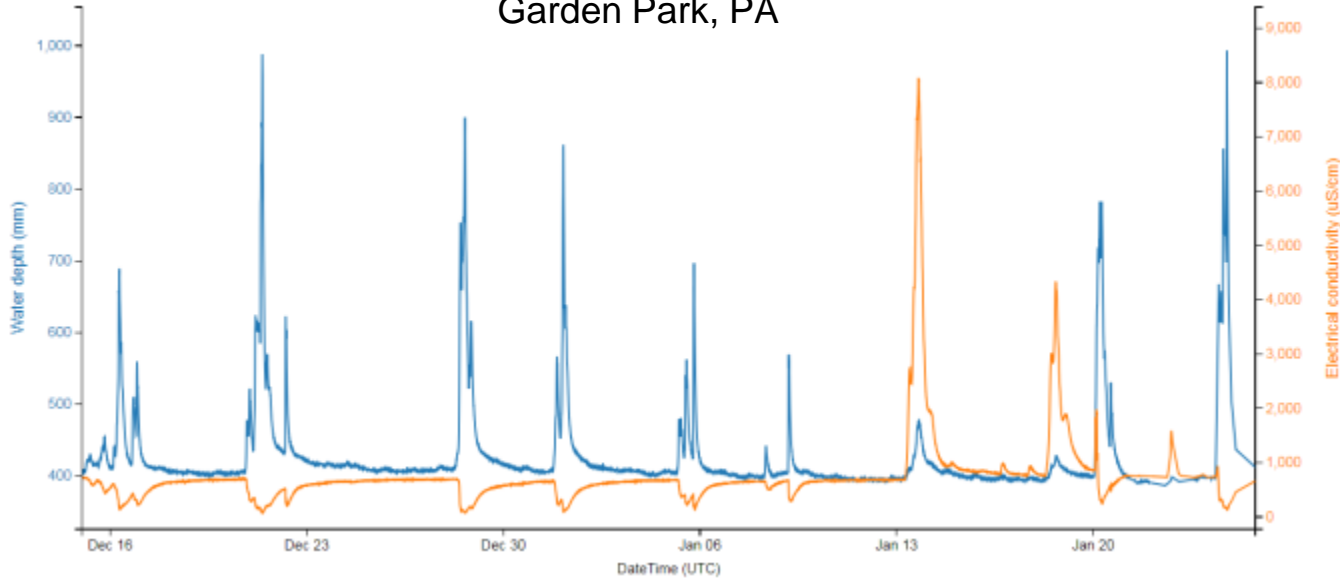


60% Urban

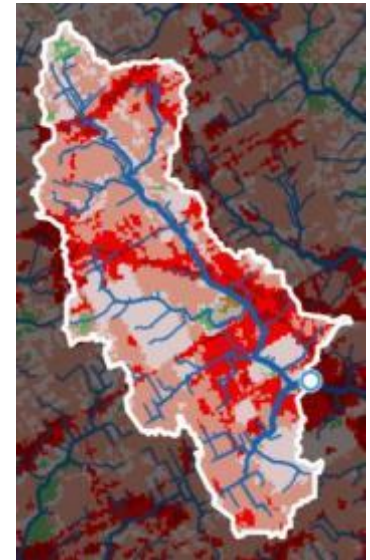


Forested versus Urban – winter conductivity spikes

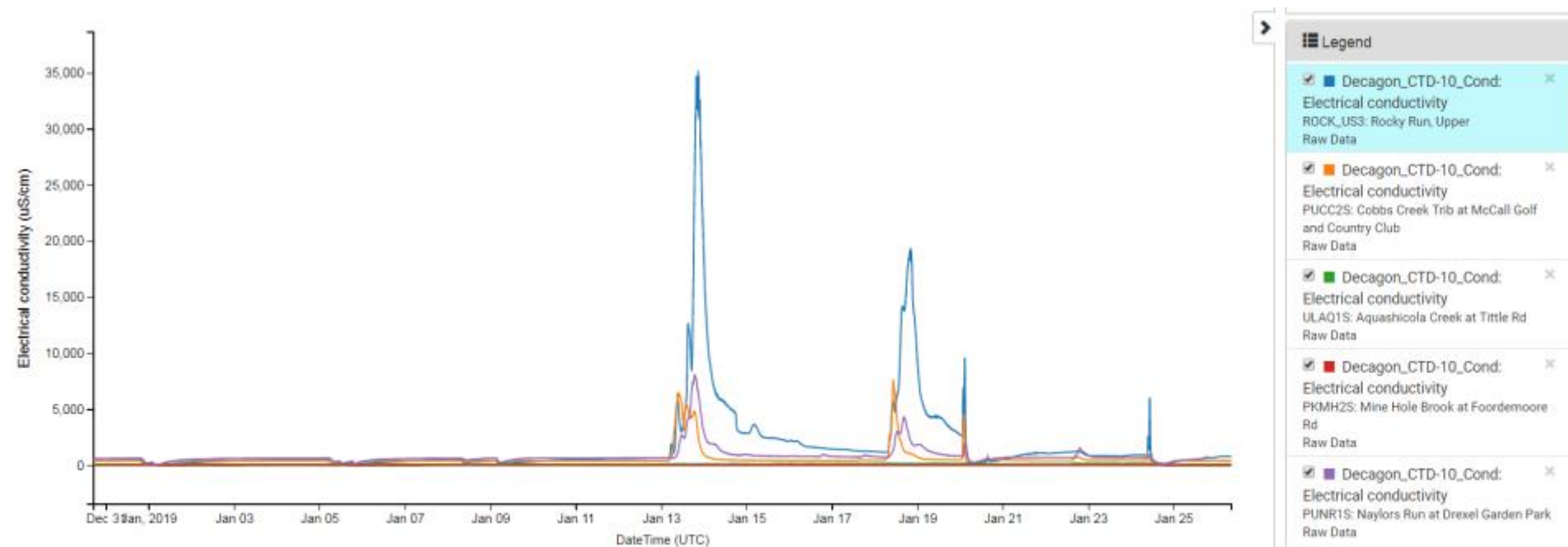
Naylor's Run, Drexel
Garden Park, PA



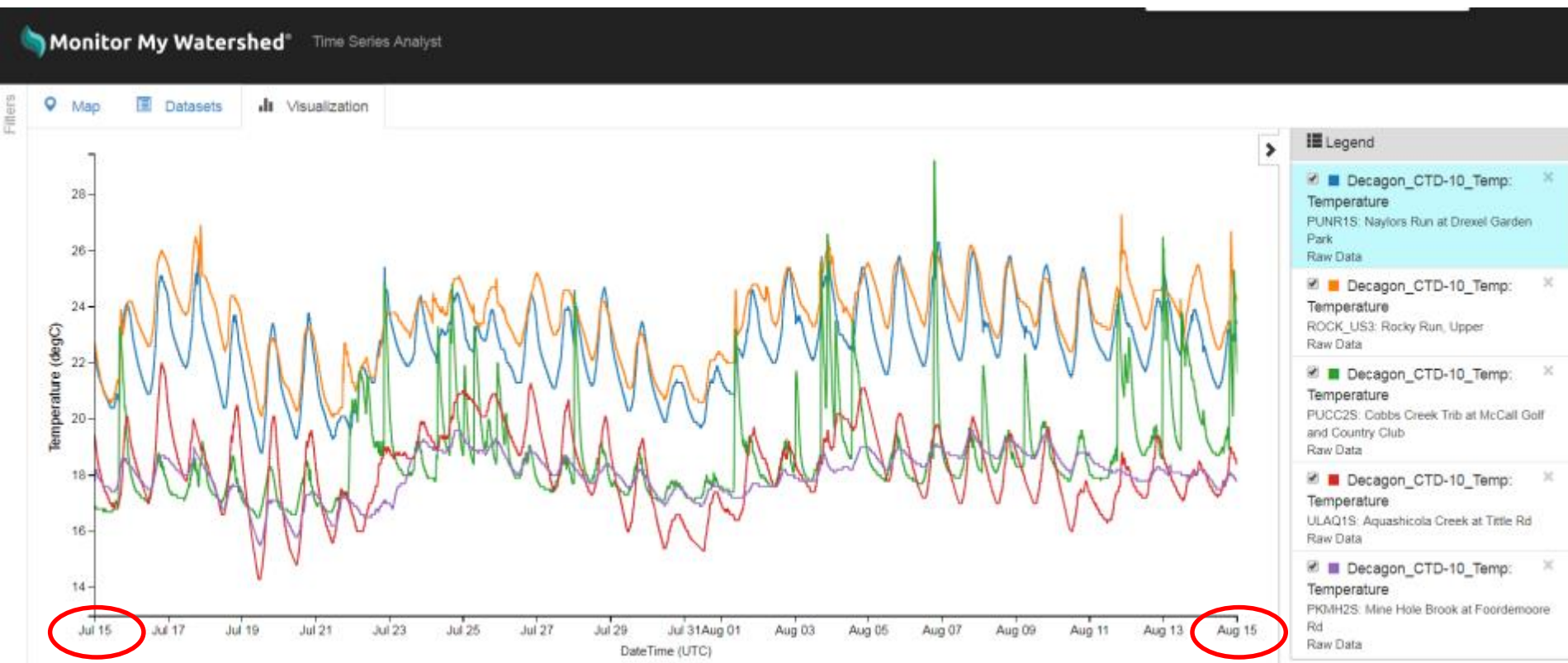
72% Urban



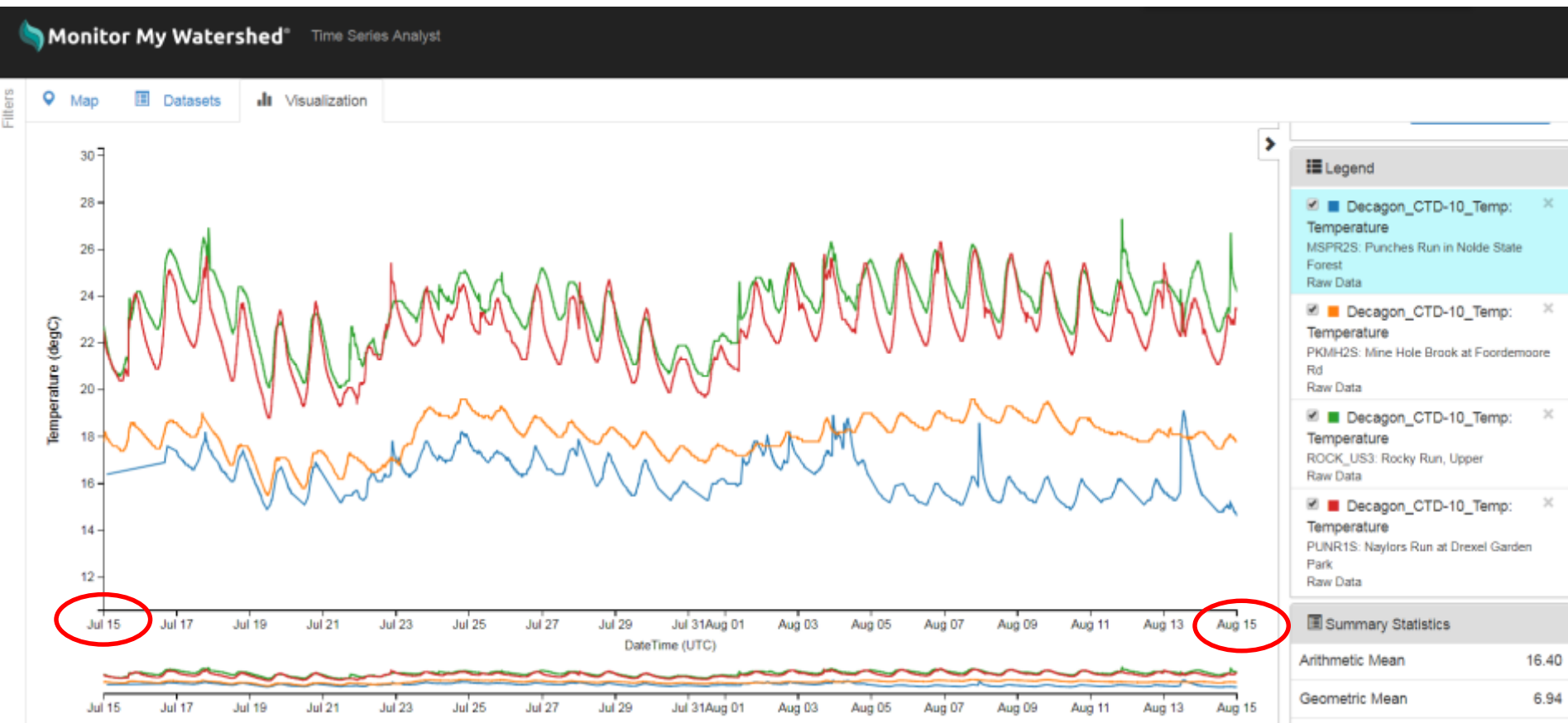
Forested vs Urban - winter conductivity spikes



Forested vs Urban - temperature differences



Forested vs Urban - temperature differences



Mayfly data logger



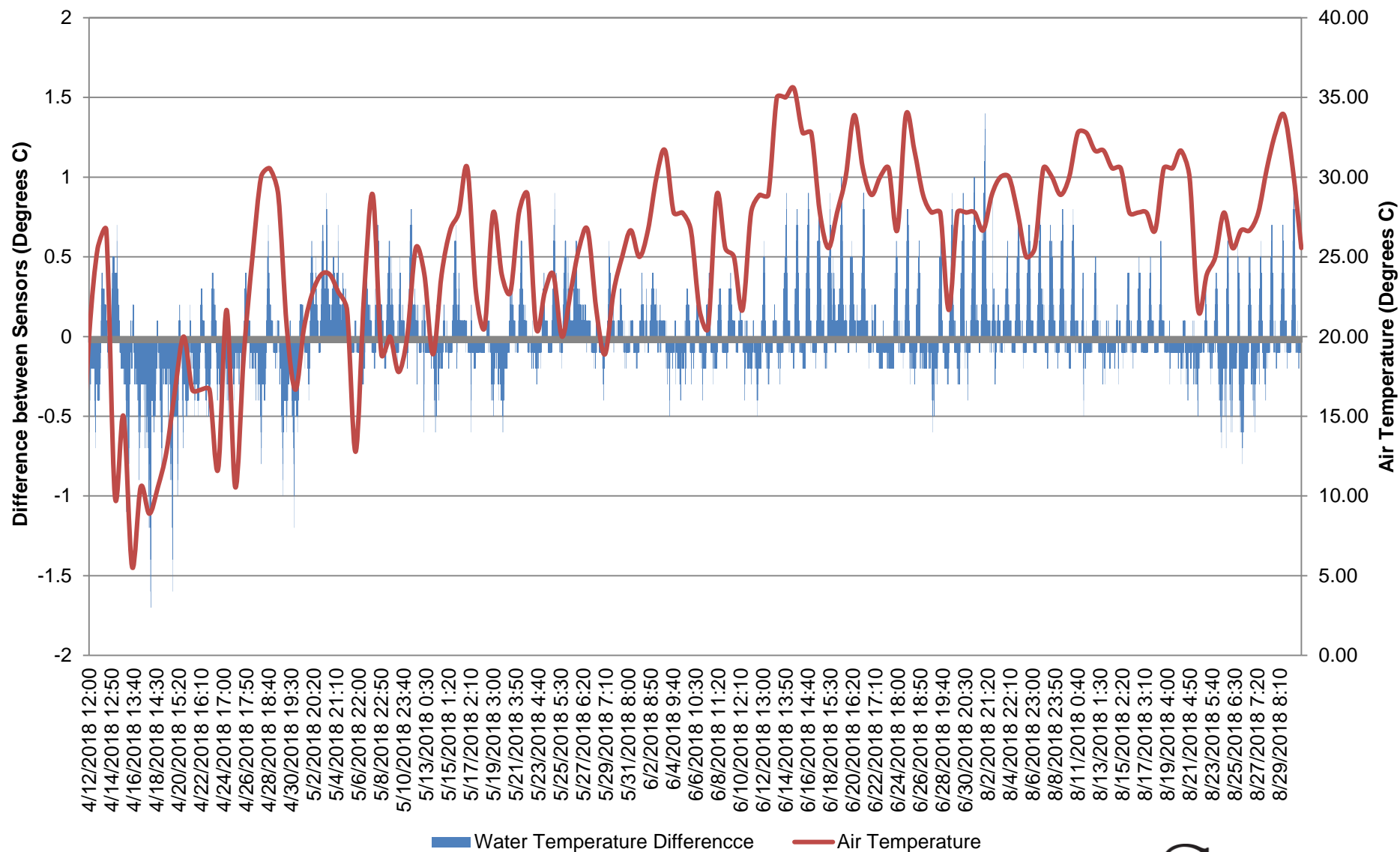
Fully compatible with Arduino IDE software

Features:

- 128K Flash memory, 16K RAM
- 28 digital I/O pins, 8 analog pins, plus 4 additional high-resolution ADC pins
- 2 serial UART ports
- microSD memory card socket
- Onboard realtime clock (RTC) (DS3231)
- Solar lipo battery charging
- Low power consumption (6.5 mA when on but idle, 0.27-0.43 mA when in sleep)
- Bee module socket
- 2 LEDs, 1 user programmable pushbutton
- 3.3v main board voltage, additional 5-volt boost circuitry for external devices
- Two 20-pin headers for accessing all available I/O pins
- 6 Grove-style sockets for easy connections to sensors and devices

*Designed by Shannon Hicks, Stroud Water Research Center

Temperature Difference between Upstream and Downstream sensors



Flood Events

